MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EMG4096 – RADAR SYSTEMS DESIGN AND ANALYSIS

(TE)

2 MARCH 2019
9:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 7 pages with 4 Questions only .

2. The student is required to answer all questions in the this question paper. Each question carries a particular marks and the distribution of the marks is given .

3. Please write all your answers in the Answer Booklet provided .

Question 1

(a) Draw a block diagram for continuous wave (CW) radar that consists of transmitter, antenna, circulator, RF receiver, mixer, etc.

Explain the main function for each of the subsystem of CW radar.

[7+7 marks]

(b) In a Frequency Modulation-Continuous Wave (FM-CW) radar configuration with triangular frequency modulation operated at centre frequency of 2.5 GHz, given that the bandwidth is 200 MHz, and the modulation frequency is 50 Hz. The target is located at 300 m from the radar system and the target is an aircraft moving with a velocity of 120 m/s,

(i) Find the intermediate frequency (f_{IF}) measured by the radar.

[3 marks]

(ii) Compute $f_{IF,UP}$ and $f_{IF,DOWN}$.

[3 marks]

(iii) Draw the instantaneous RF frequency for the above mentioned target.

[5 marks]

Continued .....

Question 2

(a) List Three (3) common SAR Image Formation Algorithms.

[3 marks]

(b)

Table Q2: Specification of MicroSAR System

Radar parameters	
Transmit power	30 dBm
Supply power	< 35 W
Supply voltage	+15 to +26 VDC
Instrument dimensions	22.1 cm x 18.5 cm x 4.6 cm
Instrument mass	2.5 kg
Total instrument mass	< 3.3 kg (including enclosure and antennas)
Modulation type	LFM-CW
Operating frequency band	C-band
Transmit center frequency	5428.76 MHz
Signal bandwidth	80-200 MHz (variable)
PRF (Pulse Repetition Frequency)	7-14 kHz (variable)
Antennas	
Type	2 x 8 patch array
Gain	15.5 dB
Beamwidth (Azimuth x Elevation)	8.5° x 50°
Size (Length x Width x Height)	35 cm x 12 cm x 0.25 cm

The specifications of compact MicroASAR builds on the design of the μSAR instrument of BYU (Brigham Young University) is shown in Table Q2.

(i) For the given bandwidth, calculate the best range resolution.

[2 marks]

(ii) Determine the best azimuth resolution able to achieve by this SAR system.

[2 marks]

Continued .....

(iii) Calculate the azimuth resolution at a range of 1.5km if conventional imaging radar system (real aperture radar) is used.

[2 marks]

(iv) Calculate the maximum detection range for this system.

[2 marks]

(c) Compare the performance of an electromechanical switch and a pin-diode switch by completing the following table:

	Electromechanical Switch	**Pin-diode Switch**
Insertion loss		
Isolation		
SWR		
Switching time		

[8 marks]

(d) The Weibull PDF for the RCS, σ, of a scattered signal from a target is given by:

$$p(a_s) = 2a_s\lambda\beta a_s{}^{2(\beta-1)}e^{-\lambda a_s{}^{2\beta}}$$

where β and λ are the shape and magnitude parameters, respectively.
Given $\beta = 0.5$ and $\lambda = 1$, find the Weibull PDF of amplitude, $p(a_s)$.

[3 marks]

(e) For the distributions given in Q2(d), what is the probability of getting a target with $a_s > 0.1$dB?

[3 marks]

Continued .....

Question 3

(a) Briefly describe what is clutter and define Signal-to-Clutter Ratio (SCR).

[5 marks]

(b) The AN/SPS-10 surface search radar has the following operating parameters:

peak transmitter power = 200 kW
antenna gain = 33.0 dB
frequency = 5.6 GHz
pulse width = 1.4 us
PRF = 625 Hz
antenna scan rate = 16 rpm
azimuth half-power beamwidth = 1.5 degrees
receiver noise bandwidth = 1 MHz
receiver noise figure = 9.88 dB
system losses ahead of the receiver = 5 dB
false alarm time = 2 days

(i) Calculate the number of hits (pulse) per scan on a stationary point target.

[2 marks]

(ii) Find P_{fa} and determine the single pulse SNR in dB required to achieve a detection probability of 0.85.

[4 marks]

(iii) Determine the Improvement Factor, $I(n_p)$ in dB (noncoherent integration).

[3 marks]

* Given the improvement factor report in Peebles as

$$[I(n_p)]_{dB} = 6.79(1+0.235P_D)(1+\frac{\log(1/P_{fa})}{46.6})\log(n_p)$$
$$(1-0.140\log(n_p)+0.018310(\log n_p)^2)$$

where n_p is the number of pulse.

(iv) Calculate the SNR for the total number of pulse as (i). The improvement factor for noncoherent integration can be written as $I(n_p)=\frac{(SNR)_1}{(SNR)_{n_p}}$, where $(SNR)_1$ is the single pulse SNR and $(SNR)_{np}$ is the SNR of np pulse.

[3 marks]

(v) Calculate the minimum detectable signal power in dBw. (Assume the SNR = 8 dB for this calculation)

[3 marks]

Continued .....

(vi) Calculate the maximum free space detection range in kilometer based on SNR_1 obtain in (ii) with a radar cross section of 1 m^2 non-fluctuating point target with single pulse.

[5 marks]

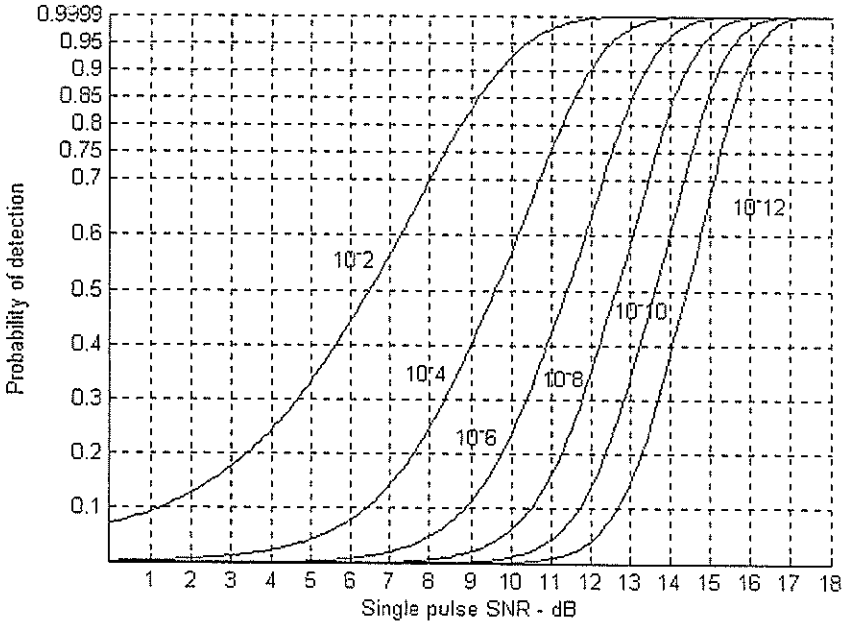

Fig. Q3: Probability of detection versus single pulse SNR for several values of P_{fa}

Continued .....

Question 4

(a) Explain the meaning of the following terms as applied in a Moving Target Indicator (MTI) radar.

(i) Blind speed.

[3 marks]

(ii) PRF (pulse repetition frequency) staggering.

[3 marks]

(b) Briefly discuss Two (2) types of Jamming technique used in electronic countermeasures.

[8 marks]

(c) Typical configurations for satellite tracking radars at various radar frequencies are listed as below.

Frequency = 5.3 GHz
SNR = 12 dB
Range = 850 km
System loss = 6 dB
Pulse width $\tau p = 10\mu s$
Noise figure = 8 dB
Antenna Gain = 50 dB

Compute the minimum peak transmit power (in dBW) required to track the satellite with RCS = 1 meter^2.

[7 marks]

(d) Briefly discuss what is Angel Echoes and list down Two (2) general classes of angel echoes.

[4 marks]

End of Paper